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PATENT APPLICATION

ATTORNEY DOCKET NO. 10018774-1

IN THE
UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Theodore I. Kamins et al

Confirmation No.: 4949

Application No.: 10/029583

Examiner: R.G. McDonald

Filing Date: Dec. 20, 2001

Group Art Unit: 1753

Title: Method of Forming One of More Nanopores for Aligning Molecules for Molecular Electronics

Mail Stop Appeal Brief-Patents
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF REPLY BRIEF

Sir:

Transmitted herewith in ***triplicate*** is the Reply Brief with respect to the Examiner's Answer mailed on Oct. 24, 2005. This Reply Brief is being filed pursuant to 37 CFR 1.193(b) within two months of the date of the Examiner's Answer.

(Note: Extensions of time are not allowed under 37 CFR 1.136(a))

(Note: Failure to file a Reply Brief will result in dismissal of the Appeal as to the claims made subject to an expressly stated new grounds of rejection.)

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Respectfully submitted,

Theodore I. Kamins et al

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PD 10018774-1, D-01056

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PATENT

PD-10018774-1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Confirmation No.: 4949

THEODORE I. KAMINS ET AL.

Serial No.: 10/029,583 Group Art Unit: 1753

Filed: December 20, 2001 Examiner: R. G. McDonald

For: METHOD OF FORMING ONE OR MORE NANOPORES FOR ALIGNING MOLECULES FOR MOLECULAR ELECTRONICS

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY BRIEF UNDER 37 C.F.R. 41.41

Sir:

Appellants submit this Reply Brief in connection with the above-referenced patent application which is on appeal to the Board of Patent Appeals and Interferences and in response to certain points raised by the Examiner in his Answer mailed October 24, 2005.

1. Response to the argument that a semiconductor device is equivalent to a molecular electronic device:

On page 13, first paragraph, of the Examiner's Answer, the Examiner states that "the prior art of record teach production of semiconductor devices which act to form electronic devices with molecular structures".

Appellants respectfully disagree for the following reasons:

A semiconductor device is one in which the properties of the semiconductor material produces the behavior of the device. The semiconductor forms the active part of the device and is not simply a piece of connected material. (This is toward any argument that tries to make Appellants' molecular device into a semiconductor device by virtue of the fact that a connecting conductor may be doped polysilicon, or a supporting mechanical substrate may be silicon, etc.) A single molecule of silicon does not have the properties of a semiconductor. (Therefore, one could use a single molecule of silicon if one could figure out how to make it work with some end group, but it would be a molecular device and ***not*** a semiconductor device.)

A semiconductor is not defined until there are enough atoms to have energy bands (typically, a valence band and a conduction band). A semiconductor is material with energy bands, each containing a range of allowed states separated by a small energy interval (much less than the energy corresponding to the ambient temperature in terms of kT, where k is the Boltzmann constant and T is the temperature in degrees Kelvin). Because the energy interval from one allowed state to the next within the allowed band is small (with respect to the energy of the ambient), the electron can access a nearby state and move to a different position by moving between energetically accessible states. In a semiconductor, a moderately large (with respect to kT) energy gap (typically a few tenths of an electron volt to several electron volts) separates allowed bands. At zero Kelvin temperature, all states in a lower band (valence band) are filled, and all states in an upper band (conduction band) are empty. At finite temperature, some electrons are thermally excited from the valence band to the conduction band, providing carriers for conduction; the empty states in the valence band (holes) also provide carriers for conduction.

The entire theory of semiconductor physics and electronics is based on the presence of a large enough number of atoms such that the energy levels within an allowed "band" of energies is much smaller than the energy corresponding to the ambient temperature.

In contrast, the theory of molecular electronics is based on the properties of a ***single*** molecule in isolation from like molecules.

A molecular device depends on properties of individual molecules, which have discrete energy levels separated by energies much greater than the energy corresponding to the ambient temperature. The electrons on the energy levels within the molecule cannot readily move to adjacent states and thus cannot move through the material classically.

Summarizing, a semiconductor device ***does not*** operate at the molecular level, with molecular structures, and the two mechanisms of operation are completely different.

2. Response to the argument that a capacitive device is
<u>equivalent to a tunnel barrier device and that all barriers are equal</u>:

On page 13, second paragraph, of the Examiner's Answer, the Examiner states that "as Appellant admits Jun et al. at least imply barriers. Appellant further points out that there would be a finite probability of tunneling. This finite probability suggests a tunnel barrier layer."

Appellants respectfully disagree for the following reasons:

A capacitor and a tunnel barrier are indeed similar physical structures, as both consist of a conductor/insulator/conductor configuration. However, they differ in one critical criteria – the thickness of the insulator, which relates directly to the rate of electrical current flow across the insulator.

A capacitor is a conductor/insulator/conductor structure that is deliberately constructed to eliminate electrical current flow across the insulator. In practice, this is achieved by constructing insulating films that are relatively thick (typically > 50 nanometers (nm)) compared to the de Broglie wavelength of an electron (~0.5 nm in most metals) and the evanescent decay length of an electron quantum mechanically tunneling into a barrier region (~0.2 nm for a 1 electron Volt (eV) barrier) [Ref: "Quantum Mechanics", Cohen-Tannoudji, Diu, Laloe, Wiley & Sons (1973)].

In contrast, a tunnel barrier is known to those skilled in the art as a conductor/insulator/conductor structure that is deliberately constructed to allow small electrical currents to flow, via quantum mechanical tunneling, across the insulator. In practice, this is achieved by constructing insulating films that are relatively thin (typically 1 nm – 5 nm total thickness) when compared to the relevant electron wavelength (~0.5 nm) and evanescent decay length (~0.2 nm) mentioned above.

The figure "Electron Tunnel Currents and Rates" attached hereto addresses this difference between tunnel barriers and capacitors. Shown are electron tunnel current densities and rates calculated [Ref: Simmons, J. Appl. Phys., 34, 6, 1793 (1963)] for a typical 2 eV high insulating barrier. For a typical microelectronic device area of 1 μm^2, a current of less than 1 pA occurs at a barrier thickness of only 3 nm. A current less than 1 pA would be very difficult to utilize in an electrical circuit; this then sets an approximate upper limit to the thickness of any useful tunnel barrier structures. Barriers of even 8.3 nm thickness, one may note, will allow approximately one electron per cm^2 every 5 billion years. The figure is not intended as "new evidence", but rather as being illustrative of the differences between a capacitor and a tunneling device.

Thus, the critical distinction between a capacitor and a tunnel barrier must be made by inspecting the thickness of the insulating layer, and the corresponding quantum mechanical electron tunnel rate. Insulating barriers less than ~5 nm may be considered tunnel barriers. Insulating barriers greater than ~10 nm may be considered capacitors. In practice, capacitor barriers are conventionally made much thicker due to constraints of pinhole-free fabrication and non-quantum mechanical, thermally activated electron transport.

Jun et al. are referring to a capacitor that functions as a capacitor, and teaches away from charge transmission.

In contrast to a capacitor, Appellants are referring to a tunnel barrier device, wherein the device operation depends on the transmission of charge through the barrier by quantum mechanical tunneling.

3. Conclusion:

The foregoing points are presented to rebut certain aspects of the Examiner's Reply. Appellants continue to maintain the patentability of their claimed invention. In view of the foregoing and the arguments presented in the Appeal Brief, Appellants respectfully request reversal of the rejections and passing of the application to issuance.

Respectfully submitted,

THEODORE I. KAMINS ET AL.

December 22, 2005

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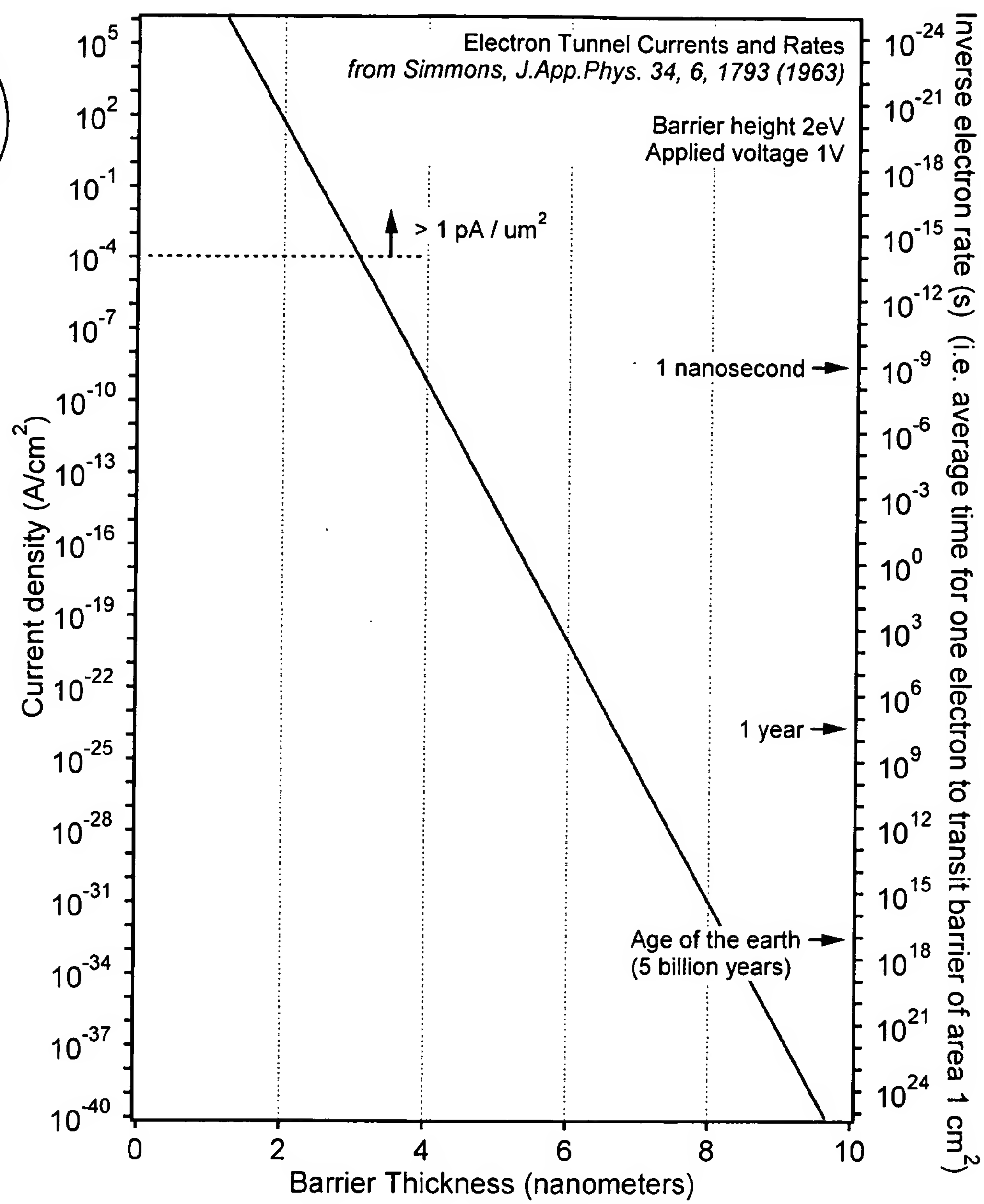
Electron Tunnel Currents and Rates
from Simmons, J.App.Phys. 34, 6, 1793 (1963)
Barrier height 2eV
Applied voltage 1V
> 1 pA / um^2
1 nanosecond
1 year
Age of the earth
(5 billion years)
Current density (A/cm^2)
Inverse electron rate (s) (i.e. average time for one electron to transit barrier of area 1 cm^2)
Barrier Thickness (nanometers)
10^{5}
10^{2}
10^{-1}
10^{-4}
10^{-7}
10^{-10}
10^{-13}
10^{-16}
10^{-19}
10^{-22}
10^{-25}
10^{-28}
10^{-31}
10^{-34}
10^{-37}
10^{-40}
10^{-24}
10^{-21}
10^{-18}
10^{-15}
10^{-12}
10^{-9}
10^{-6}
10^{-3}
10^{0}
10^{3}
10^{6}
10^{9}
10^{12}
10^{15}
10^{18}
10^{21}
10^{24}
0
2
4
6
8
10